EXHIBIT F

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Nguyen

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(54) **MONITORING VIRTUALIZED NETWORK**

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H04L 12/26 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 43/50*** (2013.01); ***H04L 43/12*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 41/24; H04L 41/26; H04L 43/04; H04L 43/12; H04L 47/10
USPC 370/235, 355, 392, 397, 398, 401, 409, 370/428; 709/238, 249
See application file for complete search history.

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Assistant Examiner — Ryan Kavleski
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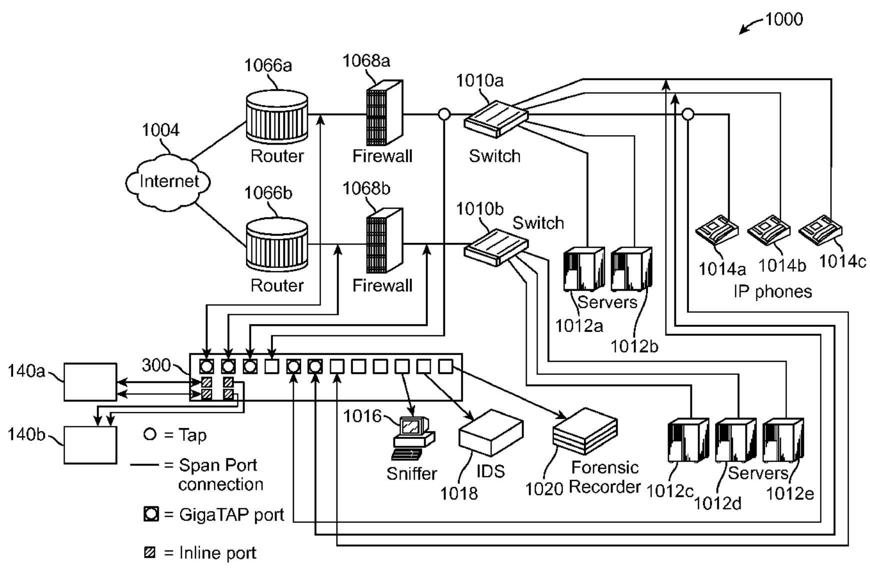
(57) **ABSTRACT**

A method of monitoring virtualized network includes receiving information regarding the virtualized network, wherein the information is received at a port of a network switch appliance, receiving a packet at a network port of the network switch appliance, and using the received information to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme, wherein the first packet processing scheme involves performing header stripping, and performing packet transmission to one of a plurality of instrument ports at the network switch appliance after the header stripping, each of the instrument ports configured for communicatively coupling to a network monitoring instrument, and wherein the second packet processing scheme involves performing packet transmission to one of the plurality of instrument ports at the network switch appliance without performing any header stripping.

45 Claims, 8 Drawing Sheets



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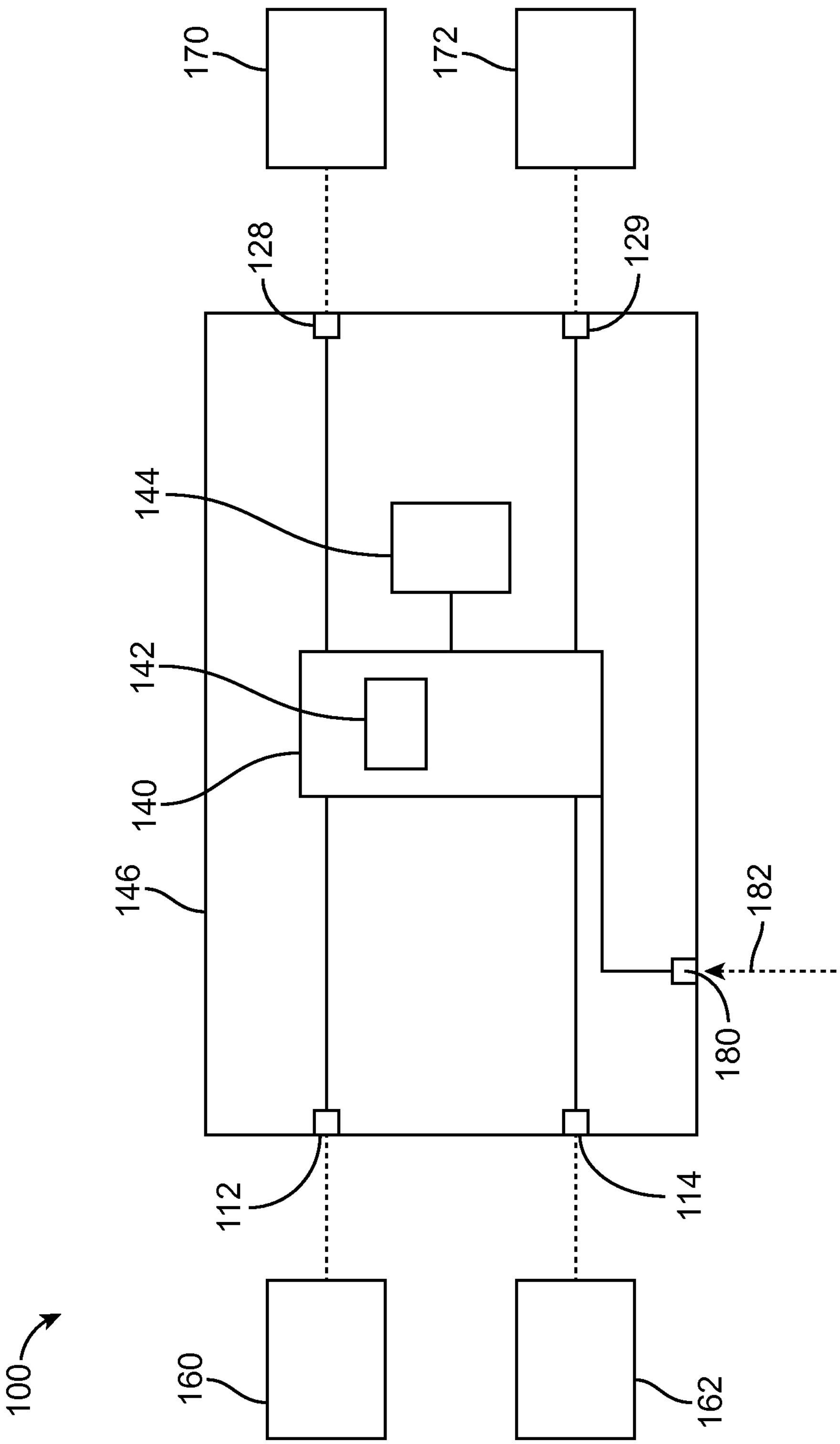

FIG. 1

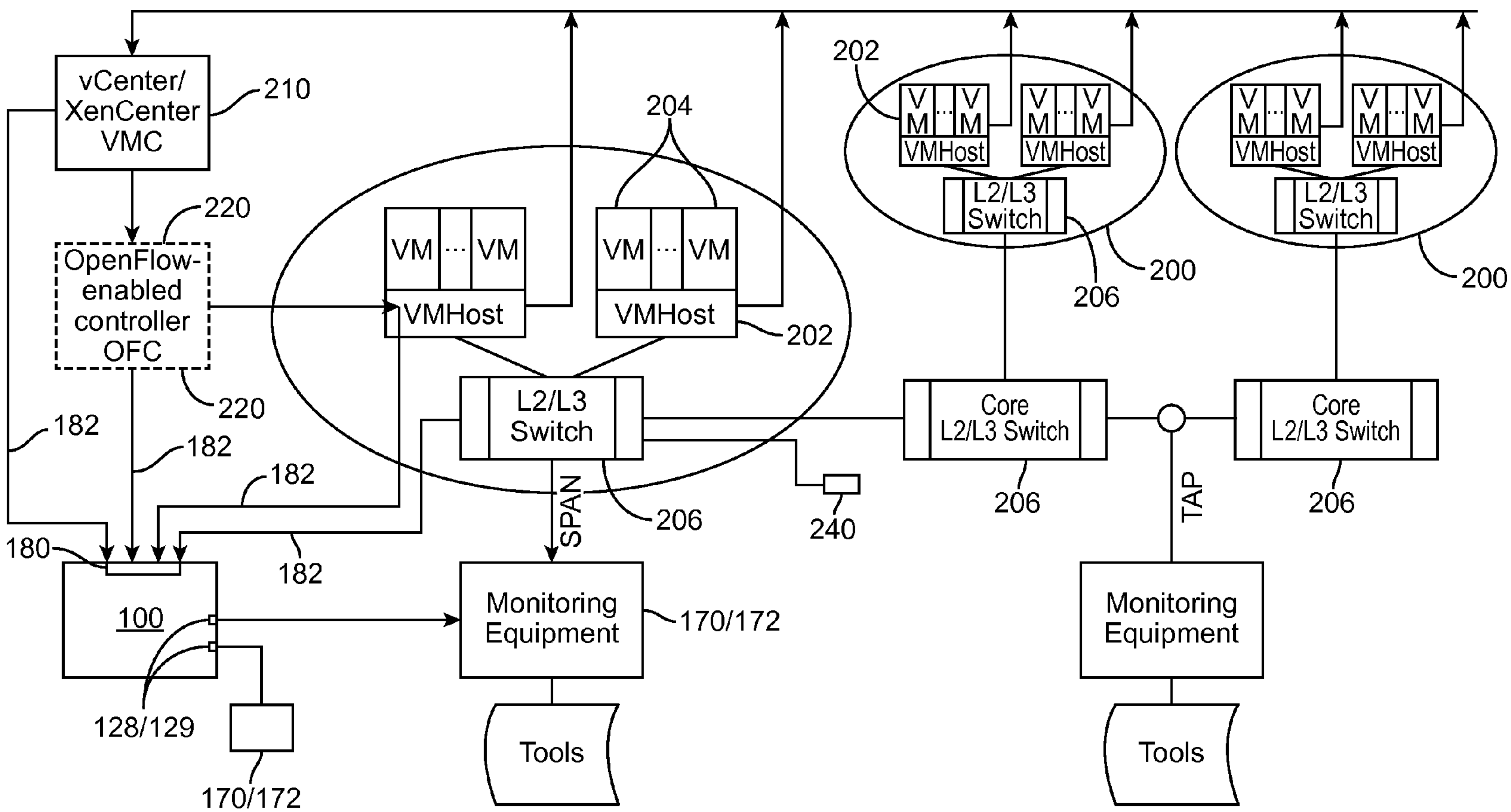
vCenter/
XenCenter
VMC
210
OpenFlow-
enabled
controller
OFC
220
220
VM
VM
VMHost
VM
VM
VMHost
204
202
202
V
M
VMHost
L2/L3
Switch
206
200
200
L2/L3
Switch
Core
L2/L3 Switch
Core
L2/L3 Switch
206
206
206
TAP
SPAN
240
182
182
182
182
180
100
128/129
170/172
Monitoring
Equipment
170/172
Monitoring
Equipment
Tools
Tools

FIG. 2

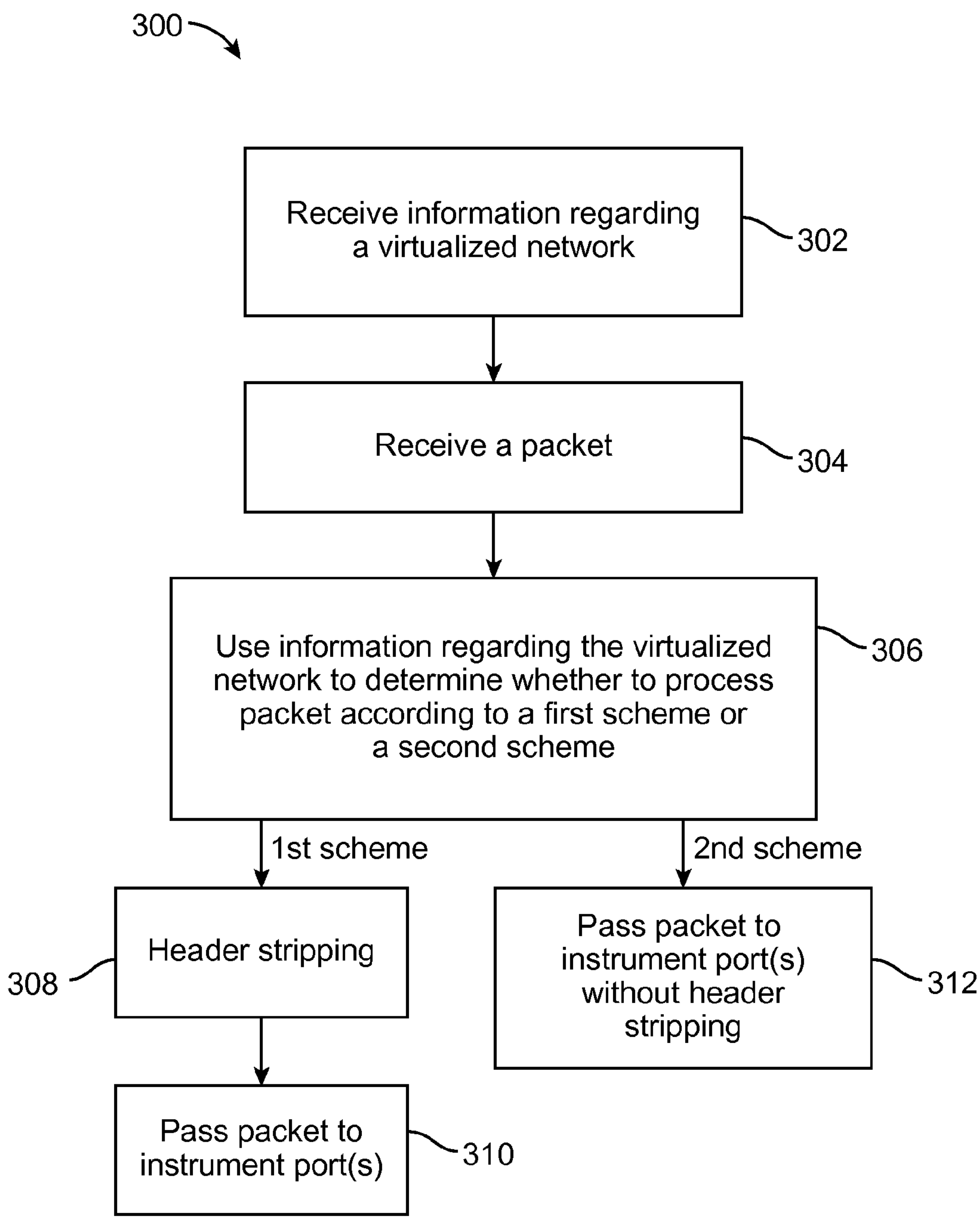
300
Receive information regarding a virtualized network
302
Receive a packet
304
Use information regarding the virtualized network to determine whether to process packet according to a first scheme or a second scheme
306
1st scheme
2nd scheme
Header stripping
308
Pass packet to instrument port(s)
310
Pass packet to instrument port(s) without header stripping
312

FIG. 3

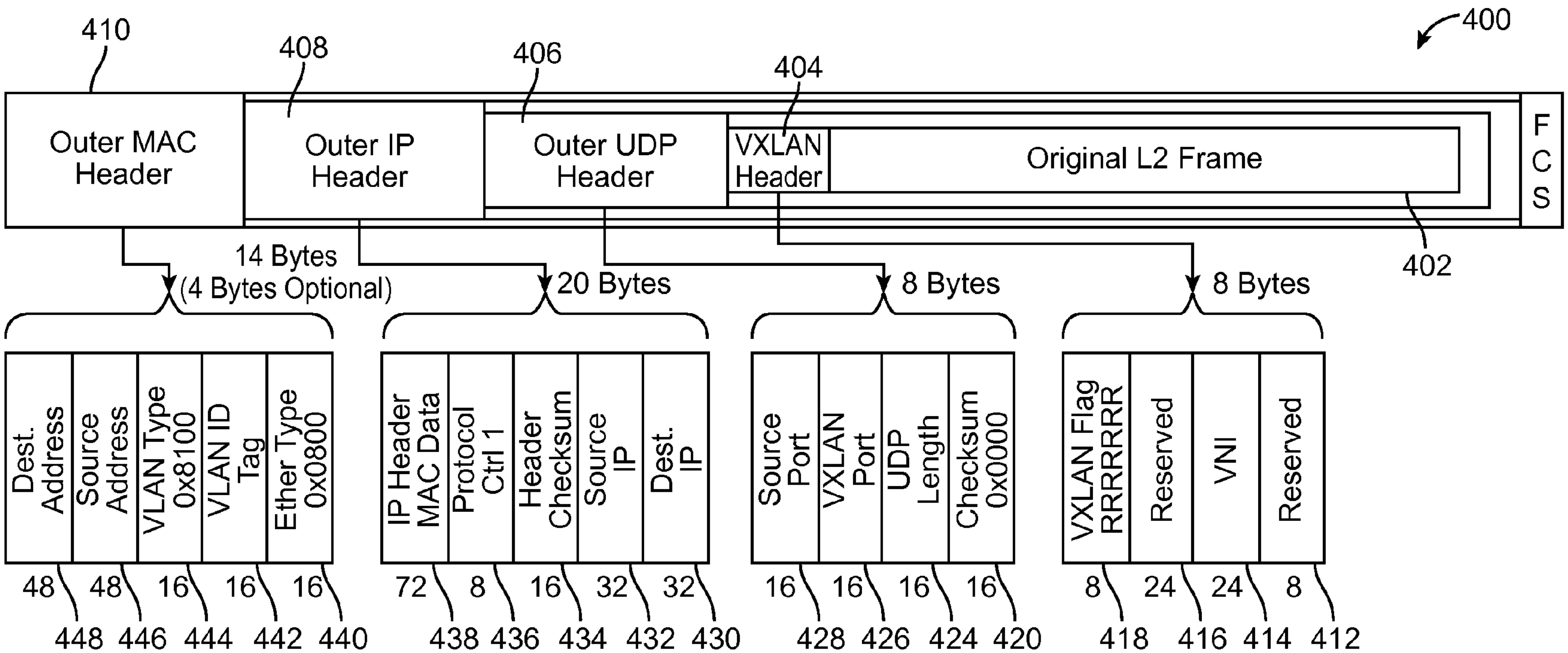
400
410
408
406
404
Outer MAC Header
Outer IP Header
Outer UDP Header
VXLAN Header
Original L2 Frame
F C S
402
14 Bytes (4 Bytes Optional)
20 Bytes
8 Bytes
8 Bytes
Dest. Address
Source Address
VLAN Type 0x8100
VLAN ID Tag
Ether Type 0x0800
IP Header MAC Data
Protocol Ctrl 1
Header Checksum
Source IP
Dest. IP
Source Port
VXLAN Port
UDP Length
Checksum 0x0000
VXLAN Flag RRRRRRR
Reserved
VNI
Reserved
48 48 16 16 16
72 8 16 32 32
16 16 16 16
8 24 24 8
448 446 444 442 440
438 436 434 432 430
428 426 424 420
418 416 414 412

FIG. 4A

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Outer Ethernet Header :                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              (Outer) Destination MAC Address                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|(Outer) Destination MAC Address |   (Outer) Source MAC Address |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                (Outer) Source MAC Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Optional Ethertype=C-Tag 802.1Q|  (Outer) VLAN Tag Information |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Ethertype 0x0800        |                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               |
Outer IPv4 Header :                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  IHL  |Type of Service |         Total Length         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Identification          |Flags|     Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live  | Protocol 0x2F |        Header Checksum       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  (Outer) Source Address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               (Outer) Destination Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
GRE Header :                                                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0| |1|0| Reserved0       | Ver |   Protocol Type 0x6558        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Tenant Network ID (TNI) |   Reserved           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Inner Ethernet Header                                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              (Inner) Destination MAC Address                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|(Inner) Destination MAC Address |  (Inner) Source MAC Address  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                (Inner) Source MAC Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Optional Ethertype=C-Tag 802.1Q| PCP |0| VID set to 0          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Ethertype 0x0800        |                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               |
Inner IPv4 Header :                                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Identification          |Flags|     Fragment Offset    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Time to Live  |   Protocol    |       Header Checksum        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Source Address                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Destination Address                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Options                     |    Padding   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Original IP Payload                        |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

FIG. 4B

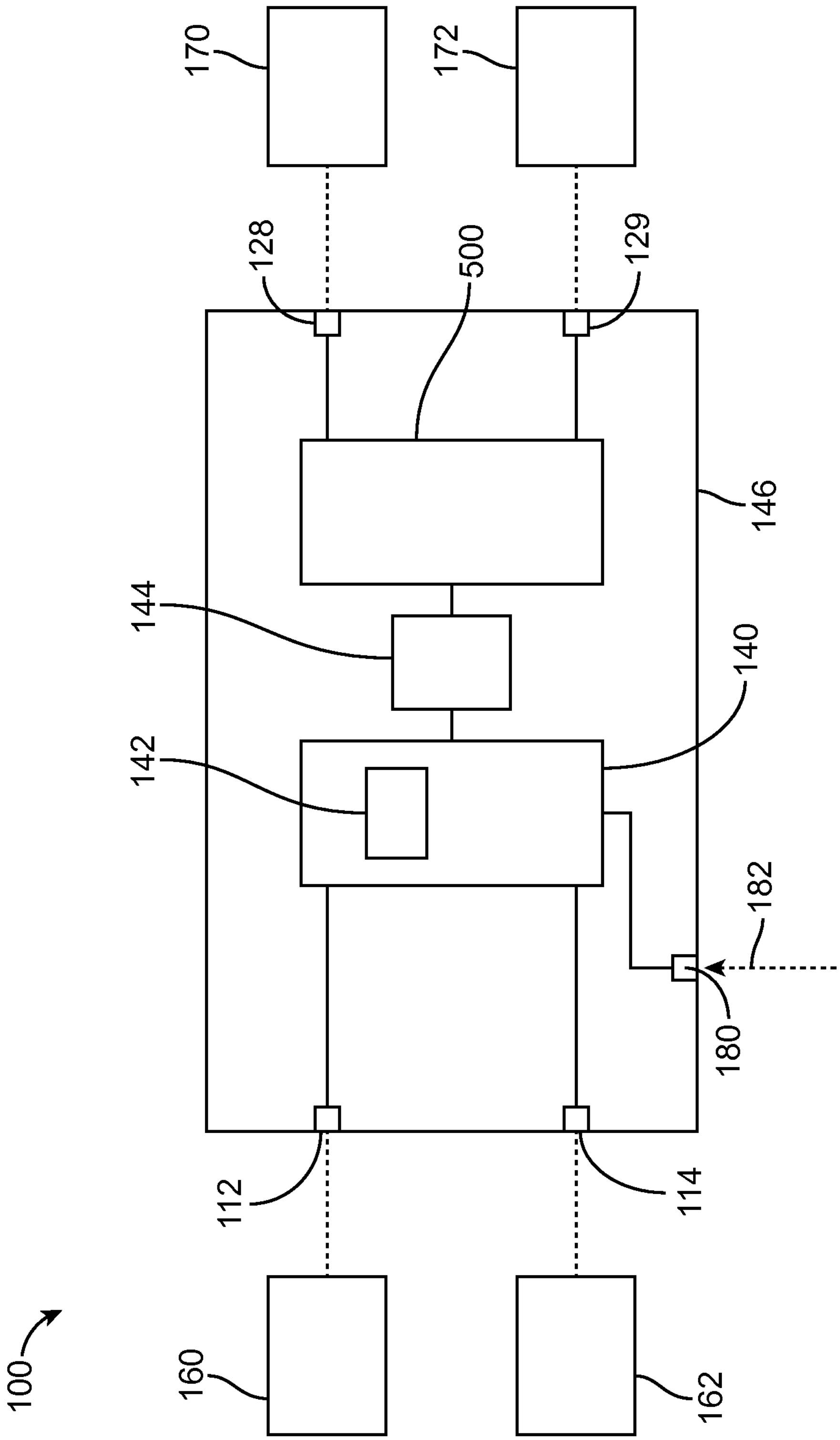

FIG. 5

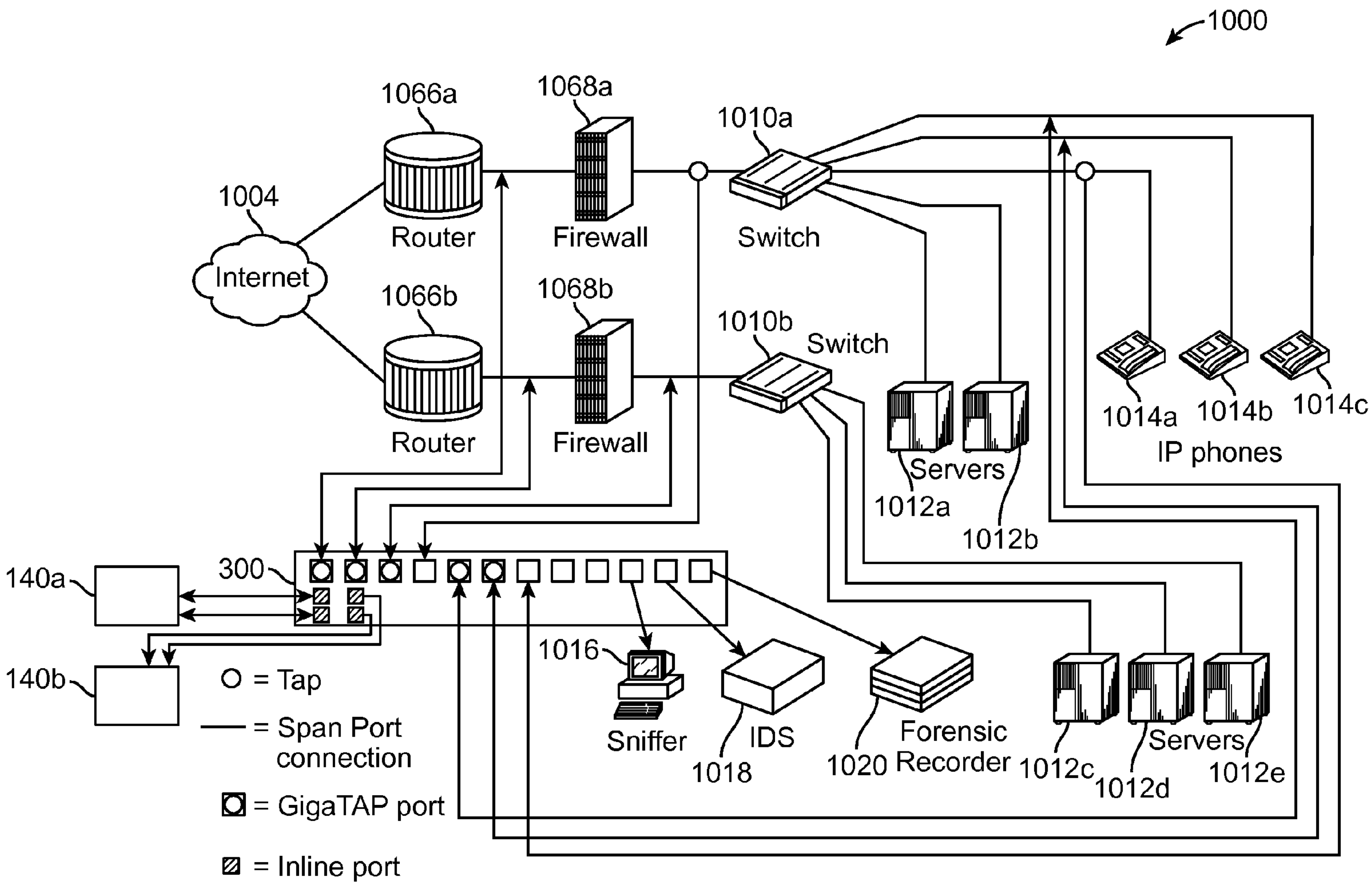
1000
1004
Internet
1066a
Router
1066b
Router
1068a
Firewall
1068b
Firewall
1010a
Switch
1010b
Switch
Servers
1012a
1012b
1014a
1014b
1014c
IP phones
300
140a
140b
○ = Tap
— = Span Port connection
= GigaTAP port
= Inline port
1016
Sniffer
1018
IDS
1020
Forensic Recorder
1012c
1012d
1012e
Servers

FIG. 6

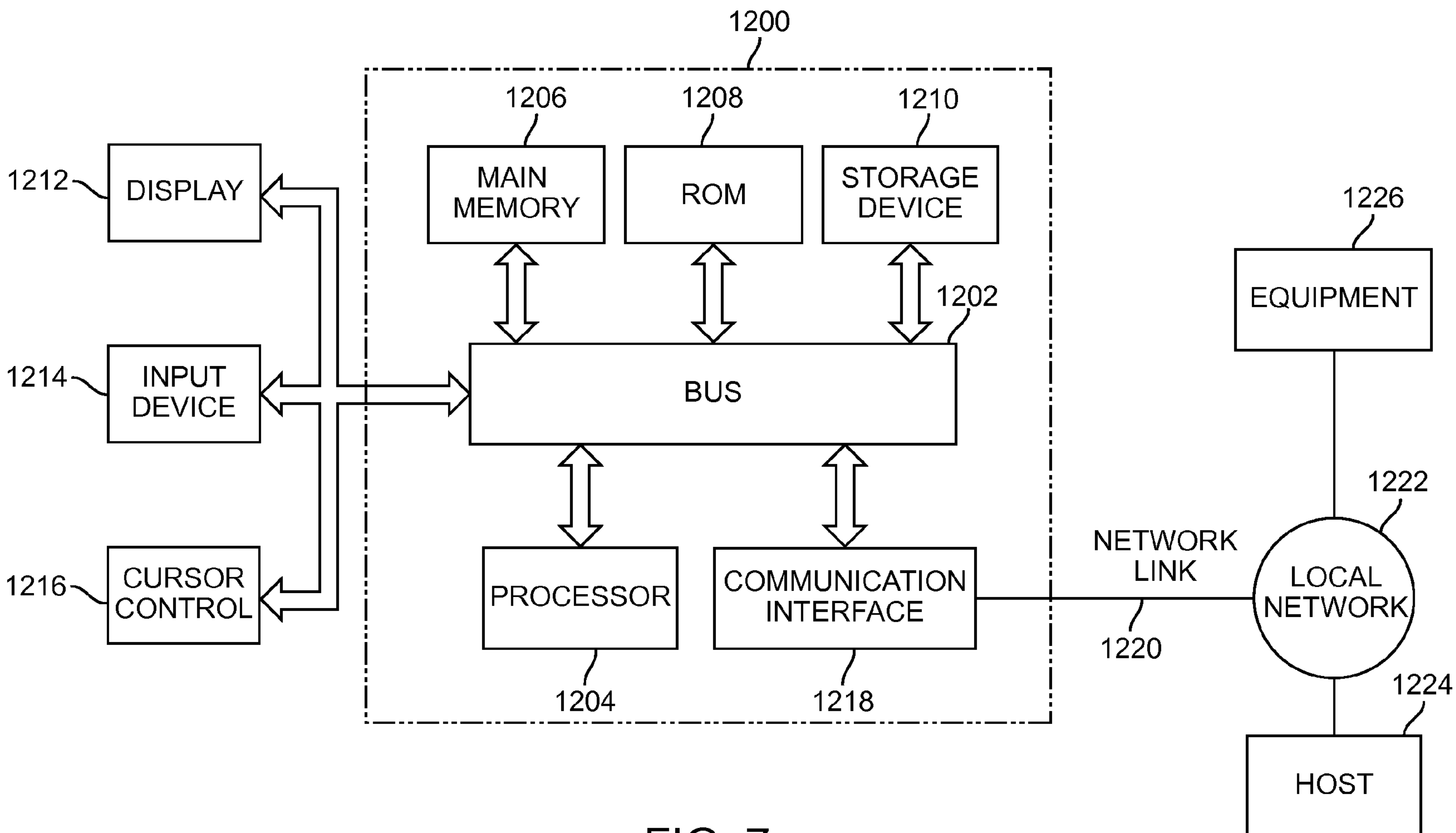
1200
1206
1208
1210
MAIN MEMORY
ROM
STORAGE DEVICE
1202
1212
DISPLAY
1214
INPUT DEVICE
BUS
1216
CURSOR CONTROL
PROCESSOR
COMMUNICATION INTERFACE
1204
1218
1226
EQUIPMENT
1222
NETWORK LINK
LOCAL NETWORK
1220
1224
HOST

FIG. 7

MONITORING VIRTUALIZED NETWORK

FIELD

This application relates generally to network switch devices, and more specifically, to systems and methods for monitoring virtualized network.

BACKGROUND

Network switches have been used to forward packets from one node to another node. Such network switch devices include a first network port for receiving packets from a first node, and a second network port for passing the packets to a second node. Some network switch devices may also include one or more instrument ports for transmitting packets to one or more instruments for monitoring network traffic.

Applicant of the subject application has determined that it may be desirable to have a network switch device that is configured to process both virtualized packets that are associated with a virtualized network, and normal packets that are associated with a non-virtualized network.

SUMMARY

In accordance with some embodiments, a method of monitoring virtualized network includes receiving information regarding the virtualized network, wherein the information is received at a port of a network switch appliance, receiving a packet at a network port of the network switch appliance, and using the received information to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme, wherein the first packet processing scheme involves performing header stripping, and performing packet transmission to one of a plurality of instrument ports at the network switch appliance after the header stripping, each of the instrument ports configured for communicatively coupling to a network monitoring instrument, and wherein the second packet processing scheme involves performing packet transmission to one of the plurality of instrument ports at the network switch appliance without performing any header stripping.

In accordance with other embodiments, an apparatus communicatively coupled to a network that includes a virtualized network includes a port for receiving information regarding the virtualized network, a network port for receiving a packet, a plurality of instrument ports, each of the instrument ports configured for communicatively coupling to a network monitoring instrument, and a processing unit configured for using the received information to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme, wherein the first packet processing scheme involves performing header stripping, and performing packet transmission to one of the plurality of instrument ports after the header stripping, and wherein the second packet processing scheme involves performing packet transmission to one of the plurality of instrument ports without performing any header stripping.

In accordance with other embodiments, an apparatus communicatively coupled to a network that includes a virtualized network includes a plurality of network ports for receiving packets, the packets including a first packet having a tunnel format, and a second packet without any tunnel format, a plurality of instrument ports, each of the instrument ports configured for communicatively coupling to a network monitoring instrument, a switch module configured to pass the first packet and the second packet to one or more of the instrument ports, and a processor for performing header stripping for the first packet having the tunnel format before the first packet is passed by the switch module to the one or more of the instrument ports.

Other and further aspects and features will be evident from reading the following detailed description of the embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate the design and utility of embodiments, in which similar elements are referred to by common reference numerals. These drawings are not necessarily drawn to scale. In order to better appreciate how the above-recited and other advantages and objects are obtained, a more particular description of the embodiments will be rendered, which are illustrated in the accompanying drawings. These drawings depict only typical embodiments and are not therefore to be considered limiting of its scope.

FIG. **1** illustrates a network appliance in accordance with some embodiments;

FIG. **2** illustrates the network appliance of FIG. **1** deployed in a network environment in accordance with some embodiments;

FIG. **3** illustrates a method performed by the network appliance of FIG. **1** in accordance with some embodiments;

FIG. **4**A shows an example of a packet with a tunnel format in accordance with some embodiments;

FIG. **4**B shows another example of a packet with a tunnel format in accordance with some embodiments;

FIG. **5** illustrates another network appliance in accordance with other embodiments;

FIG. **6** illustrates a deployment of a network appliance in accordance with some embodiments; and

FIG. **7** illustrates an example of a computer system with which embodiments described herein may be implemented.

DESCRIPTION OF THE EMBODIMENTS

Various embodiments are described hereinafter with reference to the figures. It should be noted that the figures are not drawn to scale and that elements of similar structures or functions are represented by like reference numerals throughout the figures. It should also be noted that the figures are only intended to facilitate the description of the embodiments. They are not intended as an exhaustive description of the invention or as a limitation on the scope of the invention. In addition, an illustrated embodiment needs not have all the aspects or advantages shown. An aspect or an advantage described in conjunction with a particular embodiment is not necessarily limited to that embodiment and can be practiced in any other embodiments even if not so illustrated, or not so explicitly described.

FIG. **1** illustrates a network switch device **100** in accordance with some embodiments. The network switch device **100** includes a first network port **112**, a second network port **114**, a first instrument port **128**, and a second instrument port **129**. The device **100** also includes a packet switch (switch module) **140** with a processing unit **142**, a processor **144**, and a network switch housing **146** for containing the packet switch **140** and the processor **144**. In the illustrated embodiments, the device **100** also includes other components, such as a Network PHY (not shown) coupled to each of the respective ports **112**, **114**, wherein the Network PHYs may

be considered to be parts of the packet switch **140**. Alternatively, the Network PHYs may be considered to be components that are separate from the integrated circuit **140**. The PHY is configured to connect a link layer device to a physical medium such as an optical fiber, copper cable, etc. In other embodiments, instead of the PHY, the device **100** may include an optical transceiver, or a SERDES, etc. The housing **146** allows the device **100** to be carried, transported, sold, and/or operated as a single unit. The ports **112**, **114**, **128**, **129** are located at a periphery of the housing **146**. In other embodiments, the ports **112**, **114**, **128**, **129** may be located at other locations relative to the housing **146**. Although two network ports **112**, **114** are shown, in other embodiments, the device **100** may include more than two network ports. Also, although two instrument ports **128**, **129** are shown, in other embodiments, the device **100** may include only one instrument port, or more than two instrument ports.

During use, the first network port **112** of the device **100** is communicatively coupled (e.g., via a network, such as the Internet) to a first node **160**, and the second port **114** is communicatively coupled (e.g., via a network, such as the Internet) to a second node **162**. The device **100** is configured to communicate packets between the first and second nodes **160**, **162** via the network ports **112**, **114**. Also, during use, the instrument ports **128**, **129** of the device **100** are communicatively coupled to respective instruments **170**, **172**. The instruments **170**, **172** may be directly coupled to the device **100**, or communicatively coupled to the device **100** through the network (e.g., Internet). In some cases, the device **100** is provided as a single unit that allows the device **100** to be deployed at a single point along a communication path. In the illustrated embodiments, the packet switch **140** is configured to receive packets from nodes **160**, **162** via the network ports **112**, **114**, and process the packets in accordance with a predefined scheme. For example, the packet switch **140** may pass packets received from one or more nodes to one or more instruments that are connected to respective instrument port(s) **128**, **129**. In some embodiments, one or more of the network ports **112**, **114** may be configured to receive normal packets (e.g., packets not from a virtualized network), as well as virtualized packets (e.g., packets with tunnel format that includes encapsulation of the original packets resulted from virtualization technology). In other embodiments, one or more the network ports **112**, **114** may be configured to receive only virtualized packets.

In one or more embodiments, the packet switch **140** may be any switch module that provides packet transmission in accordance with a pre-determined transmission scheme. In some embodiments, the packet switch **140** may be user-configurable such that packets may be transmitted in a one-to-one configuration (i.e., from one network port to an instrument port). As used in this specification, the term "instrument port" refers to any port that is configured to transmit packets to an instrument, wherein the instrument may be a non-pass through device (i.e., it can only receive packets intended to be communicated between two nodes, and cannot transmit such packets downstream), such as a sniffer, a network monitoring system, an application monitoring system, an intrusion detection system, a forensic storage system, an application security system, etc., or the instrument may be a pass-through device (i.e., it can receive packets, and transmit the packets back to the device **100** after the packets have been processed), such as an intrusion prevention system. In other embodiments, the packet switch **140** may be configured such that the packets may be transmitted in a one-to-many configuration (i.e., from one network port to multiple instrument ports). In other embodiments, the packet switch **140** may be configured such that the packets may be transmitted in a many-to-many configuration (i.e., from multiple network ports to multiple instrument ports). In further embodiments, the packet switch **140** may be configured such that the packets may be transmitted in a many-to-one configuration (i.e., from multiple network ports to one instrument port). In some embodiments, the one-to-one, one-to-many, many-to-many, and many-to-one configurations are all available for allowing a user to selectively configure the device **100** so that the packets (or certain types of packets) are routed according to any one of these configurations. In some embodiments, the packet movement configuration is predetermined such that when the device **100** receives the packets, the device **100** will automatically forward the packets to the ports based on the predetermined packet movement configuration (e.g., one-to-one, one-to-many, many-to-many, and many-to-one) without the need to analyze the packets (e.g., without the need to examine the header, determine the type of packets, etc.).

Examples of packet switch **140** that may be used to implement features described herein include any of the commercially available network switch devices, such as GigaVUE™, that is available at Gigamon LLC. Other examples of packet switch **140** that may be used to implement features described herein are described in U.S. patent application Ser. Nos. 12/148,481, 12/255,561, 11/123,273, 11/123,465, and 11/123,377, the entire disclosure of all of which is expressly incorporated by reference herein.

In accordance with some embodiments, the packet switch **140** may have the functionalities of a conventional packet switch except that it provides visibility into various parts of a network. Thus, embodiments of the packet switch **140** may operate like a conventional managed packet switch, but providing packet monitoring function. This is accomplished by configuring the packet switch **140** to operate as a circuit switch under certain circumstances. In some embodiments, the configuring of the managed packet switch may be performed by utilizing a CPU interface of the switch to modify appropriate registers in the switch to allow for the desired operation. Also, in some embodiments, the packet switch **140** may be an "out-of-band" network switch, which is configured to obtain packets and pass them to an instrument or to a network that is different from that associated with the original intended destination of the packets.

It should be noted that the packet switch **140** that may be used with the device **100** is not limited to the examples described above, and that other packet switches **140** with different configurations may be used as well. Also, in one or more embodiments described herein, the packet switch **140** may be implemented using an integrated circuit, such as a processor (e.g., a general purpose processor, a network processor, an ASIC processor, a FPGA processor, etc.). Thus, the term "packet switch" or "switch module" may refer to any circuit that is capable of performing the functions described herein, and should not be limited to a switch or a processor.

As shown in the figure, the network switch device **100** further includes a port **180** for receiving information **182** regarding a virtualized network. For examples, the information **182** regarding the virtualized network may be an identification of a virtual machine host, an identification of a virtual machine workload, a mapping between the virtual machine host and the virtual machine workload, or any combination of the foregoing. In some embodiments, the information **182** may be a mapping between an outer header (e.g., the addresses of the source and/or destination VM

hosts) and inner header (e.g., the addresses of the actual VM) of a packet that has a tunnel format, wherein the outer header may be due to an encapsulation of an original packet resulted from virtualizaton technology. The information **182** regarding the virtualized network may be received at the port **180** from a virtualized data center, a virtual machine host, an openflow controller, a network switch, or another device that is communicatively coupled to the port **180**. In some embodiments, the port **180** may be a separate and different port from the network ports **112**, **114**. In other embodiments, the port **180** may be a network port, like the network ports **112**, **114**, or may be implemented using one or both of the network ports **112**, **114**. In such cases, in addition to receiving the information **182**, the port **180** may also receive network traffic that are being communicated between nodes (e.g., nodes **160**, **162**). Also, in further embodiments, the device **100** may include multiple ports **180** for receiving information **182**. In some cases, one or more of the ports **180** may be used to implement the network ports **112**, **114**, thereby allowing the same port(s) **180** for receiving the information **182** to also receive network traffic.

In accordance with some embodiments, the processing unit **142** is configured to receive packets from the network ports **112**, **114**, and process the packets with respect to the information **182** regarding a virtualized network received at the port **180**. In some embodiments, the processing unit **142** may determine that a particular packet is associated with a virtualized network based on the information **182**, in which case, the packet switch **140** then processes the packet in accordance with a first packet processing scheme. In other embodiments, the processing unit **142** may determine that a particular packet is not associated with a virtualized network based on the information **182**, in which case, the packet switch **140** then processes the packet in accordance with a second packet processing scheme. In some embodiments, the first packet processing scheme may involve performing header stripping on the packet that is associated with a virtualized network using the processor **144**, and performing packet transmission to the instrument port **128** and/or the instrument port **129** at the network switch device **100** after the header stripping. Techniques for header stripping will be discussed in further detail below. Also, in some embodiments, the second packet processing scheme may involve performing packet transmission to the instrument port **128** and/or the instrument port **129** at the network switch device **100** without performing any header stripping.

In the illustrated embodiments, the processing unit **142** is illustrated as a component of the packet switch **140**. In other embodiments, the processing unit **142** may be a separate component from the packet switch **140**. The processing unit **142** may be implemented using a processor, such as a general processor, a network processor, an ASIC processor, a FPGA processor, etc. In other embodiments, the processing unit **142** may be a field processor. In further embodiments, the processing unit **142** may be a network card. Also, in some embodiments, the packet switch **140** may include ternary content-addressable memory (TCAM). The packet switch **140** may be configured to perform various packet processing functions, included but not limited to packet filtering, packet routing, packet switching, packet mirroring, packet aggregation, etc.

As discussed, the processor **144** may be used to perform header stripping in some embodiments. The processor **144** is communicatively coupled to the packet switch **140**. In other embodiments, the processor **144** may be a part of the packet switch **140**. Also, in some embodiments, the processor **144** may be a general purpose processor, a network processor, an ASIC processor, a FPGA processor, or any of other types of processor. In other embodiments, the processor **144** may be any hardware, software, or combination thereof, that is configured to perform header stripping (and optionally, other packet processing functions). In the illustrated embodiments, the processor **144** is configured to receive only packets with a tunnel format, such as that used in a virtualized network. In one implementation, the processing unit **142** or the packet switch **140** is configured to pass all packets with a tunnel format to the processor **144**, and does not pass packets without any tunnel format (e.g., packets that are not associated with a virtualized network) to the processor **144**. Upon receiving a packet with a tunnel format, the processor **144** then removes one or more headers from the packet. By means of non-limiting examples, the processor **144** may be configured to remove an outer MAC header, an outer IP header, an outer UDP header, or any combination of the foregoing, from the packet. Examples of these headers will be discussed below with reference to FIGS. **4A-4B**. In other embodiments, in addition to performing packet stripping, the processor **144** may also be configured to perform other packet processing functions on the received packet.

In the illustrated embodiments, after the processor **144** performs header stripping on the packet, the processor **144** then passes the packet back to the packet switch **140**. The packet switch **140** then transmits the packet to one or more of the instrument ports **128**, **129** according to a pre-determined transmission scheme (e.g., one-to-one, one-to-many, many-to-one, many-to-many, etc.) as discussed previously.

As discussed, the processing unit **142** may determine that a packet is not associated with a virtualized network, in which cases, the processing unit **142** or the packet switch **140** then processes the packet in accordance with the second packet processing scheme in which the packet is passed to one or more of the instrument ports **128**, **129** without performing any header stripping. Thus, in the second packet processing scheme, the packet is not passed to the processor **144** for header stripping. Such technique is advantageous because it allows the processor **144** to be dedicated to performing packet processing function(s) (e.g., header stripping) that is appropriate for only packets with tunnel format. As a result, the processor **144** can perform such function(s) very quickly and efficiently, and does not need to spend resources for processing packets to distinguish virtualized network packets from non-virtualized network packets. Also, dedicating the processor **144** for header stripping is advantageous because the packet switch **140** does not need to spend resource to perform header stripping.

As discussed, the port **180** at the network switch device **100** is configured to receive information **182** regarding a virtual network in some embodiments. The information **182** may be received from one or more devices. FIG. **2** illustrates an environment in which the network switch device **100** may be deployed. As shown in the figure, the network environment includes multiple sub-networks **200**, wherein each network **200** may include one or more hosts (e.g., VM Host) **202**. Also, each of the hosts **202** may include one or more workloads (e.g., virtual machine) **204**.

In some embodiments, the port **180** at the network switch device **100** may be configured to receive the information **182** regarding the virtual network directly or indirectly from the host(s) **202**. In other embodiments, the port **180** at the network switch device **100** may be configured to receive the information **182** regarding the virtual network directly or indirectly from a switch **206** to which the host(s) **202** is communicatively coupled. The switch **206** may be a L2/L3 switch, or any of other types of switch, in different embodi-

ments. In one implementation, the port **180** may be configured for snooping of signaling traffic used to set up, discover, or map the VM hosts to the VM targets. For example, in VXLAN network technology, IP multicast may be used to send "ARP"-like packets to find the host that hosts a particular VM target. In some network virtualization, such as VXLAN, where the signaling messages are involved for setting up the tunnel information, such signaling messages may be snooped at the L**2**/L**3** switch **206**, for reception by the network switch device **100** to obtain the tunnel information without involving a datacenter (e.g., e.g., a vCenter, a XenCenter, etc.) or an OpenFlow controller (OFC).

Also, as shown in the figure, in other embodiments, the port **180** at the network switch device **100** may be configured to receive the information **182** regarding the virtual network directly or indirectly from a datacenter (e.g., a vCenter, a XenCenter, etc.) **210** to which different the hosts **202** from the different networks **200** are communicatively coupled. In one implementation, the port **180** may be used to access the datacenter **210** to retrieve the inventory of VM targets and their relations to the VM hosts. The VM hosts may be managed in the data center(s) **210** by the VM controller, e.g. vCenter or XenCenter (referred to as VMC in the figure). The VMC knows about the hosts, workloads (VMs), and where the workloads are running. It also knows about the network identities of the hosts, and some of the workloads. The VMC may have APIs for third party vendor devices to connect to and get the inventory information, as well VM events, such as when a new workload is started, stopped, or migrated from one host to another host. Thus, any of such information may be obtained from the datacenter **210** using the port **180**.

In further embodiments, the port **180** at the network switch device **100** may be configured to receive the information **182** regarding the virtual network directly or indirectly from an OpenFlow enabled controller (OFC) **220**. In some cases, tunnel information for a packet may be set up or received by a software-defined-network (SDN) and/or OpenFlow controller. In such cases, the tunnel information may be sent from the SDN and/or OpenFlow switches to a collector, which analyzes tunnel information and provide the information **182** to the network switch device **100**. In some embodiments, the OFC and/or the network switch device **100** may subscribe to the VMC to get the information **182** about the virtualized datacenter **210**, such as workloads-to-hosts map. In such cases, the information **182** may be obtained from the VMC or from the OFC. For example, in some embodiments where the OFC is employed, the tunnel information (i.e. the mappings between the inner and outer addresses in an encapsulated packet) may be made available to the network switch device **100** by the OFC sending a copy of the open flow message to the network switch device **100**.

In other embodiments, such as Nicira/Xen/OpenVSwitch, the OFC may be used to control all the OpenVSwitches in the VM Hosts' hypervisor to set up the tunnel, e.g., via a communication channel between the OFC and the VM Host. In such cases, the switch **206** may be an OpenFlow switch, in which cases, the OpenFlow switch may send a copy the OpenFlow message to the network switch device **100**. In other embodiments, the OFC may be optional. Xen's OpenVSwitch is another technology involved in network virtualization. This solution involves using OpenFlow controller to control the OpenFlow-enabled OpenVSwitches to create a tunnel mesh using NVGRE format. Unlike VXLAN, the tunnels of NVGRE format are created by a centralized OpenFlow-enabled controller(s) which knows about the VM hosts and VM workloads. When the OpenVSwitch needs to send traffic from workload A to workload B, if it does not yet know the identity of the VM host that hosts workload B, it will ask the controller, which then sends it the necessary information to create a tunnel between VM host of A and VM host of B. Thus, in some embodiments, the information **182** may be obtained from the controller and/or from the OpenVSwitch.

It should be noted that the information **182** may be received from one device (e.g., device **202**, **206**, **210**, or **220**), or from multiple devices (e.g., any combination of the devices **202**, **206**, **210**, and **220**).

As shown in the figure, the network switch device **100** may receive a packet that is associated with a virtualized network (such as a packet that is associated with the VM Host **202**) at a network port (e.g., port **112**/**114**) or the port **170**. The network switch device **100** may also receive a packet that is not associated with any virtualized network (such as a packet from node **240**). In some embodiments, the network switch device **100** is configured to use the information **182** to determine whether a received packet is associated with a virtualized network or not.

FIG. **3** illustrates a method **300** of monitoring a virtualized network that may be performed by the network switch device **100** in accordance with some embodiments. First, the network switch device **100** receives information regarding the virtualized network (Item **302**). In the illustrated embodiments, the information regarding the virtualized network may be received at the port **180** (which may be, for example, a port dedicated for receiving the information). The information regarding the virtualized network may be stored in a non-transitory medium in the network switch device **100** in some embodiments. In other embodiments, the information regarding the virtualized network may be stored in a non-transitory medium (e.g., an external hard drive, a server, etc.) outside the network switch device **100**, wherein the non-transitory medium is communicatively coupled to the network switch device **100**.

As discussed, the information (e.g., the information **182**) regarding the virtualized network may be an identification of a virtual machine host, an identification of a virtual machine workload, a mapping between the virtual machine host and the virtual machine workload, or any combination of the foregoing. In some embodiments, the information may be a mapping between an outer header (e.g., the addresses of the source and/or destination VM hosts) and inner header (e.g., the addresses of the actual VM) of a packet that has a tunnel format, wherein the outer header may be due to an encapsulation of an original packet resulted from virtualizaton technology. In other embodiments, the information regarding the virtualized network may be any of other data that may be used to determine whether a given packet is a virtualized packet.

Next, the network switch device **100** receives a packet at a network port, such as the network port **112**, or the network port **114** (Item **304**). The network switch device **100** then uses the received information **182** regarding the virtualized network to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme (Item **306**). In some embodiments, the first packet processing scheme involves performing header stripping (Item **308**), and performing packet transmission to one of a plurality of instrument ports (e.g., instrument ports **128**, **129**) at the network switch device **100** after the header stripping (Item **310**). Also, in some embodiments, the second packet processing scheme involves performing packet transmission to one of the plurality of instrument ports (e.g.,

instrument ports **128**, **129**) at the network switch device **100** without performing any header stripping (Item **312**).

In some embodiments, when performing the act **306**, the processing unit **142** at the network switch device **100** may examine one or more fields in the packet, and may determine if the value(s) in the respective field(s) matches with value(s) in a table that is compiled using the previously received information **182**. If the value(s) from the packet matches from the value(s) in the table, then the processing unit **142** may determine that the packet is associated with a virtualized network (e.g., the packet may be from a virtual machine). In such cases, the network switch device **100** then processes the packet according to the first packet processing scheme, in which the processing unit **142** passes the packet to the processor **144**, which performs header stripping to remove headers of a tunnel format from the packet. In particular, a packet that is associated with a virtualized network may include a tunnel format that encapsulates the original traffic packet. The encapsulation due to the virtualization may include multiple headers that are added to the original packet. Thus, in the illustrated embodiments, after the processing unit **142** determines that the packet is associated with a virtualized network, the processing unit **142** then passes the packet to the processor **144** to remove the tunnel format so that the packet in its original form may be later processed.

Various techniques may be employed to determine whether a packet has a tunnel format. In one implementation, the table stored in the network switch device **100** (e.g., in a non-transitory medium assessable by the processing unit **142**) may include a list of hosts (e.g., host addresses) and corresponding workload. For example, if a virtualized network includes host A supporting virtual machines **X1**, **X2** (workload), and host B supporting virtual machines **Y1**, **Y2**, and assuming that it is desirable to monitor traffic between **X1** and **Y1** using the network switch device **100**, then the table may include the following list:

TABLE

A, X1
B, Y1

The above table may be compiled using the information **182** (e.g., host identifiers (addresses) A, B, and workload identifiers **X1**, **Y1**) received from the virtualized network when the workload is set up with the hosts. It should be noted that the host information may be dynamically changing, and therefore, the information stored in the table may also be dynamically changing accordingly. In the above example, after the table is complied, it may later be used to process packets when the network switch device **100** receives the packets. For example, the network switch device **100** may receive a packet with an outer tunnel header that includes the source and destination addresses of the hosts (e.g., A, B). In such cases, the processing unit **142** will look up the table and see if there is a match between the source and destination addresses in the outer tunnel header, and the values in the table. If there is a match (indicating that the packet is a virtualized packet with a tunnel format), the packet will then be passed to the processor **144** to strip the outer header(s).

In other embodiments, in addition to, or in the alternative to, the source and destination addresses in the outer tunnel header, the processing unit **142** may examine other fields in the packet, and look up the table to see if there are matching values in order to determine whether the packet is a virtualized packet (i.e., has a tunnel format). By means of non-limiting examples, the processing unit **142** may look up UDP port number, GRE tunnel label, any of the values in the GRE header, etc., and see if corresponding value(s) may be found in the table lookup. If a virtualized network was set up previously, the above information **182** may be transmitted to the device **100** for storage in the device **100** in table form. Thus, if there is a match, the processing unit **142** may then determine that the packet has a tunnel format.

In another example, the table may include a mapping between the outer header (e.g., the addresses of the source and destination VM hosts) and inner header (e.g., the addresses of the actual VMs which the user cares about). In such cases, the processing unit **142** will pass the packet to the processor **144** for header stripping when the information in the packet matches with the information in the mapping. Such configuration is advantageous because a host may be supporting many virtual machines, and there may be many traffic from the different virtual machines. However, a user may be interested in only traffic between certain virtual machines.

In some embodiments, a packet with a tunnel format may be a VXLAN packet that encapsulates traffic between the virtualization machine workloads (VM workloads). FIG. **4**A illustrates an example of a VXLAN packet **400** in some embodiments. As shown in the figure, the original L**2** packet **400** that a virtual machine sends out is encapsulated in the VXLAN header **402** that includes a reserved field **412**, a VNI field **414** associated with the VXLAN Segments that the virtual machine belongs to (field for VXLAN network identifier), another reserved field **416**, and VXLAN flags field **418**. The resulting packet is then wrapped in a UDP->IP->Ethernet packet for final delivery in a network. Thus, VXLAN is a tunneling scheme with the ESX hosts making up the VXLAN Tunnel End Points (VTEP). The VTEPs are responsible for encapsulating the virtual machine traffic in a VXLAN header, and stripping it off and presenting the destination virtual machine with the original L**2** packet. As shown in the figure, the encapsulation includes the following modifications from UDP, IP and Ethernet frames: an outer UDP header **406**, an outer IP header **408**, and an outer MAC header **410**. The outer UDP header **406** includes source port field **428**, VXLAN port field **426**, a UDP length field **424**, and an UDP checksum field **420**. The outer IP header **408** includes an IP header field **438**, a protocol field (for indicating that the frame includes a UDP packet) **436**, a header checksum field **434**, a source IP field (IP address of originating VXLAN Tunnel End Point (VTEP)) **432**, and a destination IP field (IP address of target VTEP) **430**. The outer MAC header **410** includes a destination address field (which may be set to a MAC address of the destination VTEP) **448**, a source address field **446**, a VLAN type field **444**, a VLAN ID tag field **442**, and an Ethertype field **440**.

In some embodiments, when the processor **144** performs header stripping on a packet, the processor **144** removes the outer UDP header **406**, the outer IP header **408**, and the outer MAC header **410**. Also, in some embodiments, the processor **144** removes the VXLAN header as well, to thereby restore the packet to its original format before it was encapsulated.

It should be noted that the tunnel format of a received packet is not limited to the example described, and that a packet received by the network switch device **100** may include other types of tunnel formats, which may have different header(s) encapsulating the original packet. For example, in other embodiments, the packet may have a NVGRE tunnel format (FIG. **4**B). Also, in other embodiments, the tunnel format may have other configurations (e.g., it may include other field(s)) that are different from the

examples shown in FIGS. **4**A, **4**B. Thus, as used in this specification, the term "tunnel format" may refer to any format that involves adding additional information (such as header(s)) to the original packet. Also, the term "tunnel header" may refer to any information that is added to the original packet. Also, in other embodiments, the original packet does not need to be a L**2** packet, and may be a packet at other levels.

In the first packet processing scheme, after header stripping is performed by the processor **144**, the processor **144** then passes the packet downstream for transmission at one or more instrument ports (e.g., instrument port **128** and/or port **129**) at the network switch device **100**. In some embodiments, the processor **144** may passes the packet back to the packet switch **140**, which then processes the packet to one or more instrument ports according to a packet transmission scheme (e.g., transmitting the packet to one or more instrument ports according a one-to-one configuration, one-to-many configuration, many-to-one configuration, many-to-many configuration, etc.). In some embodiments, after the outer header(s) of the packet has been removed by the processor **144**, the packet switch **140** then applies filters to the inner header which is the traffic of real interest. The filtered traffic can then be aggregated and/or replicated to the desired instrument ports according to a packet transmission scheme as discussed above. In some embodiments, the packet switch **140** is configured for applying first set of filters based on known outer headers (for virtualized network packets) to identify and discriminate non-virtualized network traffic from virtualized network traffic, to thereby forward the virtualized network traffic to the second packet switch **500** for further process. The packet switch **140** is also configured for applying second set of filters based on original headers (for non-virtualized network packets) to allow the traffic from physical network to be filtered and mapped to instrument ports as discussed before.

In other embodiments, the processing unit **142** at the network switch device **100** may determine, during action **306**, that the packet is not associated with a virtualized network. In such cases, the network switch device **100** (e.g., the packet switch **140**) then processes the packet according to the second packet processing scheme, in which the packet is transmitted downstream to one or more instrument ports (e.g., instrument port **128** and/or port **129**) at the network switch device **100** without performing any header stripping.

As illustrated in the above embodiments, removing the outer header(s) of a tunnel format before passing the packet to a network monitoring instrument is advantageous. This is because existing network monitoring instruments may not understand the tunnel formats. Even if a network monitoring instrument can somehow be modified to understand the formats, it would require additional resources for the instrument to process the tunnel headers. Also, the existing monitoring tools would need to be upgraded to process the original data that is encapsulated in the tunnel format. Embodiments described herein would allow existing network monitoring equipment (without modification) to process the packets even if the packets are encapsulated in a tunnel format when received at the device **100** (because the device **100** is configured to remove the tunnel headers before transmitting the packets to the network monitoring equipment).

Also, allowing the processing unit **142** to first identify packets from a virtualized network before stripping header(s) of the tunnel format associated with the virtualized network is advantageous. This is because network traffic may include a mixed of normal network traffic (e.g., the traditional network traffic) and virtualized network traffic. Accordingly, indiscriminately stripping headers from all traffic without the benefit of the functionalities of the processing unit **142** would not be desirable because this would result in removing header information in the normal network traffic.

In other embodiments, the network switch device **100** may be configured to process only packets from a virtualized network. In such cases, there may be multiple processors **144**, with each processor **144** being configured for a respective network port (e.g., network port **112**/**114**) for removing header(s) of the tunnel format for the packet received at the network port. However, such configuration may not be as desirable as the embodiments described with reference to FIGS. **1** and **5** because it would be relatively costly to add a processor (e.g., FPGA or network processor) at every network port of the network switch device **100**. Also, it may not be possible, or may be difficult, to add multiple processors for respective network ports for the network switch device **100** if it is already deployed.

In the above embodiments, after header stripping is performed for a packet by the processor **144**, the packet is then returned to the packet switch **140** so that the packet switch **140** can process the packet according to a packet transmission scheme (e.g., transmitting the packet to one or more instrument ports according a one-to-one configuration, one-to-many configuration, many-to-one configuration, many-to-many configuration, etc.). Having the separate processor **144** perform heading stripping is advantageous because the processor **144** can do this task non-discriminatively, and therefore in a very efficient manner. Also, the packet switch **140** can perform filtering functions on packets efficiently because it can apply the same filtering functions (those for normal packets) to packets that is received from a virtualized network due to the fact that the processor **144** has removed the encapsulation for these packets.

In other embodiments, instead of returning the packet back to the packet switch **140**, after header stripping is performed for the packet by the processor **144**, the processor **144** may pass the packet to another packet switch **500** that is different from the packet switch **140** (FIG. **5**). In the illustrated embodiments, the network switch device **100** further includes the packet switch **500** for processing the packet according to a packet transmission scheme (e.g., transmitting the packet to one or more instrument ports according a one-to-one configuration, one-to-many configuration, many-to-one configuration, many-to-many configuration, etc.). In such cases, the packet switch **140** is configured to pass packets that do not have any tunnel format to one or more of the instrument ports, and the packet switch **500** is configured to pass packets to one or more of the instrument ports after the headers associated with a tunnel format have been removed from these packets. Thus, the packet switch **500** and the packet switch **140** may be configured to perform some of the same packet processing functions, such as passing of packets to one or more instrument ports according to a packet transmission scheme. In some embodiments, in addition to performing packet transmission, both the packet switch **140** and the packet switch **500** may be configured to filter and replicate traffic. In some embodiments, after the outer header(s) of the packet has been removed by the processor **144**, the packet switch **500** then applies filters to the inner header which is the traffic of real interest. The filtered traffic can then be aggregated and/or replicated to the desired instrument ports according to a packet transmission scheme as discussed above.

In some embodiments, the packet switch **140** is configured for applying first set of filters based on known outer headers (for virtualized network packets) to identify and discriminate non-virtualized network traffic from virtualized network traffic, to thereby forward the virtualized network traffic to the processor **144** and the second packet switch **500** for further process. The packet switch **140** is also configured for applying second set of filters based on original headers (for non-virtualized network packets) to allow the traffic from physical network to be filtered and mapped to instrument ports as discussed before. Allowing only virtualized network traffic of interest for processing by the second packet switch **500** will significantly reduce the workload required of the second packet switch **500** (or the number of resources needed for the packet switch **500**).

In the illustrated embodiments, the processor **144** is communicatively coupled to the packet switch **500**, which is a separate component from the processor **144**. In other embodiments, the processor **144** may be implemented as a part of the packet switch **500**. Also, in further embodiments, the packet switch **500** may be located outside the housing of the network switch device **100**, and is communicatively coupled to the processor **144** located inside the housing of the network switch device **100**. In some embodiments, each of the packet switch **140** and the packet switch **500** may be implemented using a high speed and/or high density ASIC. Using ASIC processor to implement the packet switch **140/500** is advantageous over FPGA processor because ASIC processor may be more powerful for handling packets filtering. Also, in some embodiments, the processor **144** may be implemented using a custom FPGA network processor. In some embodiments, the FPGA processor may be cheaper and/or use less power than a non-FPGA network processor.

In one or more embodiments, the network switch device **100** may optionally be configured to insert stripped header(s) to other part(s) of a packet. For example, in some embodiments, the processor **144** may receive a packet with an outer header (O), an inner header (I), and a payload (P), as follow: O-I-P. The processor **144** then strips the outer header, and may insert it to the end of the packet to obtain the format: I-P-O. The processor **144** then transmits the modified packet with the new format back to the network switch **140/500** for packet filtering. In some embodiments, the network switch **140/500** is configured to perform packet filtering based on the information in the header (I), and so the extra information in the outer header (O) at the end of the packet will not affect the filtering of the packet by the network switch **140/500**. For example, the network switch **140/500** may perform packet filtering to identify HTTP packets, TCP packets, etc., and transmit them to the appropriate instrument port(s) according to pre-determined packet transmission scheme. In some embodiments, the modified packet with the format I-P-O is received by a network monitoring instrument that is communicatively coupled to an instrument port at the network switch device **100**. The network monitoring instrument may use the information in the outer header (O) to analyze the network traffic, such as to re-generate the virtualized network traffic using addresses of the hosts in the outer header (O).

Also, in one or more embodiments, the network switch device **100** may optionally be configured to perform additional filtering on the packet after the header stripping. For example, in some embodiments, the processor **144** may receive a packet with an outer header (O), an inner header (I), and a payload (P)—i.e., with the format O-I-P. In such cases, the processor **144** may strip the outer header O so that the revised packet has the format I-P. The processor **144** may also process the packet to determine if there is any field in the header I, or between the header I and the payload P that is a specialized field. For example, the processor **144** may identify a value h1 in a specialized field in one packet, and a value h2 in the specialized field in another packet. In such cases, when transmitting the revised packet to the packet switch **140/500**, the processor **144** may also be configured to transmit meta data associated with the values in the specialized field. In the above example, when transmitting the first packet with the value h1 in the specialized field, the processor **144** may also transmit meta data M1, to the packet switch **140/500**. Similarly, when transmitting the second packet with the value h2 in the specialized field, the processor **144** may also transmit meta data M2, to the packet switch **140/500**. When the packet switch **140/500** receives the packets with the meta data, the packet switch **140/500** may then perform filtering based on the information in the header I, and/or based on the meta data. For example, the packet switch **140/500** may pass the packet to one or more of the instrument ports based on a first filtering criteria that the packet is a HTTP packet, and a second filtering criteria that the meta data value is M1. In other examples, the first filtering criteria may be based on other types of packet (e.g., TCP packet, etc.).

FIG. **6** shows the deployment of the network switch device **100** in a network environment **1000** in accordance with some embodiments. The Internet **1004** is coupled via routers **1006***a-b* and firewalls **1068***a-b* to two switches **1010***a* and **1010***b*. Switch **1010***a* is coupled to servers **1012***a-b* and IP phones **1014***a-c*. Switch **1010***b* is coupled to servers **1012***c-e*. A sniffer **1016**, an IDS **1018** and a forensic recorder **1020** (collectively, "non-pass through instruments") are coupled to the device **100**. As illustrated in FIG. **6**, there is a reduction on the number of non-pass through instruments in this deployment as compared to a conventional configuration (in which there may be one or more non-pass through instruments between router **1066***a* and firewall **1068***a*, one or more non-pass through instruments between firewall **1068***a* and switch **1010***a*, one or more non-pass through instruments between router **1066***b* and firewall **1068***b*, and firewall **1068***b* and switch **1010***b*) because the same non-pass through instruments can now access information anywhere in the network environment **1000** through the device **100**. The user has complete flexibility to channel whatever traffic to whatever instrument or groups of non-pass through instruments, using the any-to-any, any-to-many and many-to-one capability of the system in accordance with the different embodiments described herein. For example, all the conversations of the IP phones **1014***a-c* can be easily configured to be sent to an IDS **1018**. It is also possible that traffic inside a particular IP phone **1014***a-c* connection can be sent to a sniffer **1016**, and Intrusion Detection System **1018** and a forensic recorder **1020** simultaneously via the one-to-many function.

In some embodiments, when using the device **100**, one or more non-pass through instruments (such as IDS, sniffer, forensic recorder, etc.) may be connected to instrument port(s), and one or more pass through instruments **140***a*, **140***b* (e.g., IPS) may be connected to other instrument port(s) (e.g., inline port(s)). Such configuration allows non-pass through instrument(s) and pass through instrument(s) to simultaneously monitor the network traffic. Each non-pass through instrument is in listening mode (i.e., it receives packets intended to be communicated between two nodes), and each pass through instrument is in pass-thru mode (i.e., it receives packets intended to be communicated between two nodes, processes them, and then pass the packets

downstream towards the intended recipient node). In some cases, by having both an IDS and an IPS connected to the device **100**, the device **100** can compare whether the IDS or the IPS sees more threats, and/or can have a redundant protection such that if the IPS misses any threat, the IDS may pick it up.

Computer System Architecture

FIG. **7** is a block diagram that illustrates an embodiment of a computer system **1200** upon which embodiments described herein may be implemented. For example, in some embodiments, the computer system **1200** may be used to implement one or more functions of the processing unit **142**, or one or more functions of the switch **140** described herein. Computer system **1200** includes a bus **1202** or other communication mechanism for communicating information, and a processor **1204** coupled with the bus **1202** for processing information. The processor **1204** may be used to perform various functions described herein. For example, in some embodiments, the processor **1204** may receive input from a user for configuring a network component (e.g., the component **380**).

The computer system **1200** also includes a main memory **1206**, such as a random access memory (RAM) or other dynamic storage device, coupled to the bus **1202** for storing information and instructions to be executed by the processor **1204**. The main memory **1206** also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by the processor **1204**. The computer system **1200** further includes a read only memory (ROM) **1208** or other static storage device coupled to the bus **1202** for storing static information and instructions for the processor **1204**. A data storage device **1210**, such as a magnetic disk or optical disk, is provided and coupled to the bus **1202** for storing information and instructions.

The computer system **1200** may be coupled via the bus **1202** to a display **1212**, such as a cathode ray tube (CRT) or a LCD monitor, for displaying information to a user. An input device **1214**, including alphanumeric and other keys, is coupled to the bus **1202** for communicating information and command selections to processor **1204**. Another type of user input device is cursor control **1216**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **1204** and for controlling cursor movement on display **1212**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allows the device to specify positions in a plane.

The computer system **1200** may be used for performing various functions in accordance with the embodiments described herein. According to one embodiment, such use is provided by computer system **1200** in response to processor **1204** executing one or more sequences of one or more instructions contained in the main memory **1206**. Such instructions may be read into the main memory **1206** from another computer-readable medium, such as storage device **1210**. Execution of the sequences of instructions contained in the main memory **1206** causes the processor **1204** to perform the process steps described herein. One or more processors in a multi-processing arrangement may also be employed to execute the sequences of instructions contained in the main memory **1206**. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions to implement features of the embodiments described herein. Thus, embodiments described herein are not limited to any specific combination of hardware circuitry and software.

The term "computer-readable medium" as used herein refers to any medium that participates in providing instructions to the processor **1204** for execution. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. Non-volatile media includes, for example, optical or magnetic disks, such as the storage device **1210**. A non-volatile medium may be considered to be an example of a non-transitory medium. Volatile media includes dynamic memory, such as the main memory **1206**. A volatile medium may be considered to be another example of a non-transitory medium. Transmission media includes coaxial cables, copper wire and fiber optics, including the wires that comprise the bus **1202**. Transmission media can also take the form of acoustic or light waves, such as those generated during radio wave and infrared data communications.

Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, or any other magnetic medium, a CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

Various forms of computer-readable media may be involved in carrying one or more sequences of one or more instructions to the processor **1204** for execution. For example, the instructions may initially be carried on a magnetic disk of a remote computer. The remote computer can load the instructions into its dynamic memory and send the instructions over a telephone line using a modem. A modem local to the computer system **1200** can receive the data on the telephone line and use an infrared transmitter to convert the data to an infrared signal. An infrared detector coupled to the bus **1202** can receive the data carried in the infrared signal and place the data on the bus **1202**. The bus **1202** carries the data to the main memory **1206**, from which the processor **1204** retrieves and executes the instructions. The instructions received by the main memory **1206** may optionally be stored on the storage device **1210** either before or after execution by the processor **1204**.

The computer system **1200** also includes a communication interface **1218** coupled to the bus **1202**. The communication interface **1218** provides a two-way data communication coupling to a network link **1220** that is connected to a local network **1222**. For example, the communication interface **1218** may be an integrated services digital network (ISDN) card or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, the communication interface **1218** may be a local area network (LAN) card to provide a data communication connection to a compatible LAN. Wireless links may also be implemented. In any such implementation, the communication interface **1218** sends and receives electrical, electromagnetic or optical signals that carry data streams representing various types of information.

The network link **1220** typically provides data communication through one or more networks to other devices. For example, the network link **1220** may provide a connection through local network **1222** to a host computer **1224** or to equipment **1226** such as a radiation beam source or a switch operatively coupled to a radiation beam source. The data streams transported over the network link **1220** can comprise electrical, electromagnetic or optical signals. The signals through the various networks and the signals on the network link **1220** and through the communication interface **1218**, which carry data to and from the computer system

1200, are exemplary forms of carrier waves transporting the information. The computer system 1200 can send messages and receive data, including program code, through the network(s), the network link 1220, and the communication interface 1218.

It should be noted that when a "packet" is described in this application, it should be understood that it may refer to the original packet that is transmitted from a node, or a copy of it.

It should be noted that the terms "first", "second", etc., are used to refer to different things, and do not necessarily refer to the order of things.

Although particular embodiments have been shown and described, it will be understood that they are not intended to limit the claimed inventions, and it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the claimed inventions. The specification and drawings are, accordingly, to be regarded in an illustrative rather than restrictive sense. The claimed inventions are intended to cover alternatives, modifications, and equivalents.

What is claimed:

1. A method of monitoring virtualized network, comprising:

receiving information regarding the virtualized network along with a packet having a header at a port of a network switch appliance, the virtualized network contained within one or more physical hosts supporting a virtualized environment, wherein the network switch appliance is configured to receive the packet in an out-of-band configuration; and

using the received information to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme, wherein said using the received information includes determining to process the packet using the first packet processing scheme in an event a header of the packet matches the received information and process the packet using the second packet processing scheme in an event the header does not match the received information;

wherein the first packet processing scheme involves performing header stripping to remove the header of the packet, the header being part of the packet when the packet is received at the port, and performing packet transmission to one of a plurality of instrument ports at the network switch appliance after the header stripping, each of the instrument ports configured for communicatively coupling to a network monitoring instrument; and

wherein the second packet processing scheme involves performing transmission of the packet having the header to one of the plurality of instrument ports at the network switch appliance without performing any header stripping.

2. The method of claim 1, wherein the act of using the received information comprises using the information to determine whether the packet is associated with the virtualized network or not.

3. The method of claim 2, wherein the packet is determined to be associated with the virtualized network, and the packet is processed according to the first packet processing scheme.

4. The method of claim 3, wherein:

the packet comprises an outer Media Access Control (MAC) header;

the act of performing header stripping comprises removing the outer MAC header of the packet; and

the act of performing the packet transmission comprises transmitting the packet to the one of the plurality of instrument ports after the outer MAC header has been removed from the packet.

5. The method of claim 3, wherein:

the packet comprises an outer Internet Protocol (IP) header;

the act of performing header stripping comprises removing the outer IP header of the packet; and

the act of performing the packet transmission comprises transmitting the packet to the one of the plurality of instrument ports after the outer IP header has been removed from the packet.

6. The method of claim 3, wherein:

the packet comprises an outer User Datagram Protocol (UDP) header;

the act of performing header stripping comprises removing the outer UDP header of the packet; and

the act of performing the packet transmission comprises transmitting the packet to the one of the plurality of instrument ports after the outer UDP header has been removed from the packet.

7. The method of claim 2, wherein the packet is determined not to be associated with the virtualized network, and the packet is processed according to the second packet processing scheme.

8. The method of claim 1, wherein:

the packet comprises an outer Media Access Control (MAC) header, an outer Internet Protocol (IP) header, an outer User Datagram Protocol (UDP) header, and a Virtual Extensible LAN (VXLAN) header; and

the act of performing header stripping comprises removing the outer MAC header, the outer IP header, the outer UDP header, and the VXLAN header from the packet.

9. The method of claim 1, wherein the header stripping includes removing one or more tunnel headers.

10. The method of claim 9, wherein the one or more tunnel headers comprise one or more Network Virtualization using Generic Routing Encapsulation (NVGRE) headers.

11. The method of claim 1, wherein the information comprises one or more of an identification of a virtual machine host, an identification of a virtual machine workload, and a mapping between the virtual machine host and the virtual machine workload.

12. The method of claim 1, wherein the information is obtained from a data center controller, a virtual machine host, an openflow controller, a Software-Defined Network (SDN) controller, or a network switch.

13. The method of claim 1, wherein the header stripping is performed by one or more processors configured to receive only packets with tunnel format.

14. The method of claim 1, wherein the packet transmission in the first packet processing scheme or the second packet processing scheme is performed to:

transmit the packet received at the port to one of the plurality of instrument ports;

transmit the packet received at the port to multiple ones of the plurality of instrument ports;

transmit the packet received at the port and another packet received at another port to one of the plurality of instrument ports; or

transmit the packet received at the port and the other packet received at the other port to multiple ones of the plurality of instrument ports.

15. The method of claim 1, wherein said performing packet transmission after the header stripping to one of the plurality of instrument ports includes transmitting the packet if the packet satisfies the filtering criteria, the filtering criteria including a specified field in the packet and metadata having a value associated with an instrument port of the plurality of instrument ports.

16. An apparatus communicatively coupled to a network that includes a virtualized network, comprising:

a port for receiving information regarding the virtualized network along with a packet having a header, the virtualized network contained within one or more physical hosts supporting a virtualized environment, wherein the apparatus is configured to receive the packet in an out-of-band configuration;

a plurality of instrument ports, each of the instrument ports configured for communicatively coupling to a network monitoring instrument; and

a processing unit configured for using the received information to determine whether to process the packet according to a first packet processing scheme or a second packet processing scheme, wherein the processing unit is configured to determine to process the packet using the first packet processing scheme in an event the header of the packet matches the received information and using the second packet processing scheme in an event the header does not match the received information;

wherein the first packet processing scheme involves performing header stripping to remove the header of the packet and performing packet transmission to one of the plurality of instrument ports after the header stripping; and

wherein the second packet processing scheme involves performing transmission of the packet having the header to one of the plurality of instrument ports without performing any header stripping.

17. The apparatus of claim 16, wherein the processing unit is configured for using the received information to determine whether the packet is associated with the virtualized network or not.

18. The apparatus of claim 16, further comprising a processor for performing the header stripping.

19. The apparatus of claim 18, wherein:

the packet comprises an outer Media Access Control (MAC) header; and

the processor is configured for performing the header stripping by removing the outer MAC header of the packet before the packet transmission is performed to pass the packet to the one of the plurality of instrument ports.

20. The apparatus of claim 18, wherein:

the packet comprises an outer Internet Protocol (IP) header; and

the processor is configured for performing the header stripping by removing the outer IP header of the packet before the packet transmission is performed to pass the packet to the one of the plurality of instrument ports.

21. The apparatus of claim 18, wherein:

the packet comprises an outer User Datagram Protocol (UDP) header; and

the processor is configured for performing the header stripping by removing the outer UDP header of the packet before the packet transmission is performed to pass the packet to the one of the plurality of instrument ports.

22. The apparatus of claim 18, wherein the packet is not associated with the virtualized network, and the processing unit is configured to by-pass the processor.

23. The apparatus of claim 18, wherein:

the packet comprises an outer Media Access Control (MAC) header, an outer Internet Protocol (IP) header, an outer User Datagram Protocol (UDP) header, and a Virtual Extensible LAN (VXLAN) header; and

the processor is configured for performing the header stripping by removing the outer MAC header, the outer IP header, the outer UDP header, and the VXLAN header from the packet.

24. The apparatus of claim 18, wherein the processor is configured to receive only packets with tunnel format.

25. The apparatus of claim 16, wherein the header stripping includes removing one or more tunnel headers.

26. The apparatus of claim 25, wherein the one or more tunnel headers comprise one or more Network Virtualization using Generic Routing Encapsulation (NVGRE) headers.

27. The apparatus of claim 16, wherein the information comprises one or more of an identification of a virtual machine host, an identification of a virtual machine workload, and a mapping between the virtual machine host and the virtual machine workload.

28. The apparatus of claim 16, wherein the port is configured to receive the information from a data center controller, a virtual machine host, an openflow controller, a Software-Defined Network (SDN) controller, or a network switch.

29. The apparatus of claim 16, further comprising a switch module for performing the packet transmission in the first packet processing scheme or the second packet processing scheme, wherein the switching module is configured to:

transmit the packet received at the port to one of the plurality of instrument ports;

transmit the packet received at the port to multiple ones of the plurality of instrument ports;

transmit the packet received at the port and another packet received at another port to one of the plurality of instrument ports; or transmit the packet received at the port and the other packet received at the other port to multiple ones of the plurality of instrument ports.

30. The apparatus of claim 29, wherein the processing unit is a part of the switch module.

31. An apparatus communicatively coupled to a network that includes a virtualized network, comprising:

a plurality of ports to receive information regarding the virtualized network along with packets, the packets including a first packet having a tunnel format, and a second packet without any tunnel format, wherein the first packet and the second packet each include a header upon receipt, wherein the apparatus is configured to receive the packets in an out-of-band configuration;

a plurality of instrument ports, each of the instrument ports to be communicatively coupled to a network monitoring instrument;

a switch module configured to pass the first packet and the second packet to one or more of the instrument ports; and

a processor configured to perform header stripping for the first packet having the tunnel format before the first packet is passed by the switch module to the one or more of the instrument ports, the header stripping performed to remove the header of the first packet that matches information regarding the virtualized network stored at the apparatus, the header being part of the first packet when the first packet is received at the appara-

tus, and wherein the processor is configured to pass the second packet including the header to the one or more of the instrument ports without stripping the header of the second packet in an event the header does not match the received information.

32. The apparatus of claim **31**, wherein the processor is configured to receive and process packets with the tunnel format, and the switch module is configured to avoid passing packets without the tunnel format to the processor.

33. The apparatus of claim **31**, wherein:

the first packet comprises an outer Media Access Control (MAC) header; and

the processor is configured for performing the header stripping by removing the outer MAC header of the first packet.

34. The apparatus of claim **31**, wherein:

the first packet comprises an outer Internet Protocol (IP) header; and

the processor is configured for performing the header stripping by removing the outer IP header of the first packet.

35. The apparatus of claim **31**, wherein:

the first packet comprises an outer User Datagram Protocol (UDP) header; and

the processor is configured for performing the header stripping by removing the outer UDP header of the first packet.

36. The apparatus of claim **31**, wherein the second packet is not associated with the virtualized network, and the switch module is configured pass the second packet downstream without going through the processor.

37. The apparatus of claim **31**, wherein:

the first packet comprises an outer Media Access Control (MAC) header, an outer Internet Protocol (IP) header, an outer User Datagram Protocol (UDP) header, and a Virtual Extensible LAN (VXLAN) header; and

the processor is configured for performing the header stripping by removing the outer MAC header, the outer IP header, the outer UDP header, and the VXLAN header from the first packet.

38. The apparatus of claim **31**, wherein the processor is configured to perform header stripping by removing one or more tunnel headers.

39. The apparatus of claim **38**, wherein the one or more tunnel headers comprise one or more Network Virtualization using Generic Routing Encapsulation (NVGRE) headers.

40. The apparatus of claim **31**, further comprising a port for receiving information regarding the virtualized network.

41. The apparatus of claim **40**, wherein the information comprises one or more of an identification of a virtual machine host, an identification of a virtual machine workload, and a mapping between the virtual machine host and the virtual machine workload.

42. The apparatus of claim **40**, wherein the port is configured to receive the information from a data center controller, a virtual machine host, an openflow controller, a Software-Defined Network (SDN) controller, or a network switch.

43. The apparatus of claim **31**, wherein the switch module is configured to:

transmit the first packet or the second packet received at one of the networks port to one of the plurality of instrument ports in a one-to-one configuration;

transmit the first packet or the second packet received at one of the ports to multiple ones of the plurality of instrument ports in a one-to-many configuration;

transmit the first packet or the second packet received at one of the ports, and another packet received at another one of the ports, to one of the plurality of instrument ports in a many-to-one configuration; or

transmit the first packet or the second packet received at one of the ports, and the other packet received at the other one of the ports, to multiple ones of the plurality of instrument ports in a many-to-many configuration.

44. The apparatus of claim **31**, further comprising a processing unit configured for determining whether to process the packets according to a first packet processing scheme or a second packet processing scheme;

wherein the first packet processing scheme involves using the processor to perform the header stripping; and

wherein the second packet processing scheme does not involve using the processor to perform header stripping.

45. The apparatus of claim **44**, wherein the processing unit is a part of the switch module.

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